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Andrew J. MacGregor
Janet J. Tang
Amber L. Dougherty
Michael R. Galarneau

Naval Health Research Center

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Naval Health Research Center
140 Sylvester Road
San Diego, California 92106-3521

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Deployment-related injury and posttraumatic stress disorder in US military personnel

Andrew J. MacGregor *, Janet J. Tang, Amber L. Dougherty, Michael R. Galarneau

Department of Medical Modeling, Simulation and Mission Support, Naval Health Research Center, San Diego, CA, United States

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ABSTRACT

Background: The current military conflicts in Iraq and Afghanistan have resulted in the most US casualties since the Vietnam War. Previous research on the association between deployment-related injury and posttraumatic stress disorder (PTSD) has yielded mixed results.

Objectives: To examine the effect of battle injury (BI) relative to non-battle injury (NBI) on the manifestation of PTSD symptoms in military personnel and to assess the demographic, injury-specific, and pre-injury factors associated with PTSD following a BI.

Patients and methods: A total of 3403 personnel with deployment-related injury (1777 BI and 1626 NBI) were identified from the Expeditionary Medical Encounter Database. Records were electronically matched to Post-Deployment Health Assessment (PDHA) data completed 1–6 months post-injury. The PTSD screening outcome was identified using a four-item screening tool on the PDHA.

Results: Compared to those with NBI, personnel with BI had more severe injuries, reported higher levels of combat exposure, and had higher rates of positive PTSD screen. After adjusting for covariates, personnel with BI were twice as likely to screen positive for PTSD compared to those with NBI (odds ratio [OR], 2.10; 95% confidence interval [CI], 1.60–2.75). In multivariable analysis among battle-injured personnel only, moderate and serious-severe injury (OR, 1.49; 95% CI, 1.12–2.00 and OR, 1.64; 95% CI, 1.01–2.68, respectively), previous mental health diagnosis within 1 year of deployment (OR, 2.69; 95% CI, 1.50–4.81), and previous BI (OR, 1.96; 95% CI, 1.22–3.16) predicted a positive PTSD screen.

Conclusions: Military personnel with BI have increased odds of positive PTSD screen following combat deployment compared to those with NBI. Post-deployment health questionnaires may benefit from questions that specifically address whether service members experienced an injury during combat.

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Introduction

Posttraumatic stress disorder (PTSD), an anxiety disorder resulting from exposure to a traumatic event, is a frequent psychological consequence of current military operations.[1] Psychological morbidity in wartime has been documented for hundreds of years[2,3] and was described in detail following twentieth century conflicts,[2,4–6] with PTSD diagnosis formalized in the DSM-III after the Vietnam War.[7–9] More recently, elevated rates of PTSD have been found in personnel deployed to the 1990 Persian Gulf War,[10] as well as in those deployed in support of post-September 11, 2001 military conflicts, particularly Operation Iraqi Freedom (OIF). Hoge et al. found that 19% of returning US service members from OIF reported a mental health problem, compared with 11% from concurrent military operations in Afghanistan and 8% from other locations.[11] In this same study, nearly 10% reported PTSD-like symptoms. A later study on OIF and Operation Enduring Freedom (OEF) veterans by Seal et al. found that 25% of a US veteran population received a mental health diagnosis of any kind, and 13% were diagnosed with PTSD.[12]

The relationship between deployment-related injury and PTSD is of particular interest because of increased survivability from combat wounds,[13] but studies examining this relationship have yielded mixed results. Early studies from World Wars I and II suggested that injured soldiers may be less likely to suffer from psychological morbidity.[6,14] Further, an Israeli study found that injured soldiers showed minimal psychological disturbances.[15] Studies of PTSD among Vietnam veterans, however, have identified a two- to three-fold greater lifetime prevalence of PTSD symptoms in the injured compared with uninjured.[16,17] In another Israeli study, researchers examined PTSD risk among combat-injured soldiers after controlling for combat exposure and demonstrated more than eight-fold increased risk of PTSD among those with combat injury compared with those uninjured.[18]

* Corresponding author at: Naval Health Research Center, 140 Sylvester Road, San Diego, CA 92106, United States. Tel.: +1 619 459 9928; fax: +1 619 553 8378.
E-mail addresses: andrew.macgregor@med.navy.mil, macgregor1014@gmail.com (A.J. MacGregor).

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Two recent studies used clinical records of deployment-related injury and identified a positive association between risk of PTSD and injury severity, but these studies were limited by medical utilization data[19] and small sample size.[20] The effect of injury mechanism, battle injury (BI) or non-battle injury (NBI), independent of the physical injury is unclear, since previous studies either combined BI and NBI or failed to account for differences in injury severity and combat exposure.[19–21] Further, although some studies have suggested injury-specific predictors of PTSD, such as head wounds and objective injury severity,[19,20,22] a thorough multivariable analysis assessing potential predictors and confounders has not been conducted.

The continued military operations in Iraq and Afghanistan, coupled with significant injury rates from these conflicts, make the study of physical injury and PTSD of paramount importance. The identification of PTSD predictors following physical injury may be useful in targeting high-risk subgroups for screening and intervention. The purpose of the present study was to examine the association between deployment-related injury and PTSD in a large sample of injured OIF veterans. Specific objectives were to (1) identify the effect of BI versus NBI in the expression of PTSD; and (2) evaluate demographic, injury-specific, and pre-injury predictors of PTSD among personnel with BI. This study was approved by the Institutional Review Board at Naval Health Research Center (NHRC), San Diego, CA.

Patients and methods

Study sample

The Expeditionary Medical Encounter Database (EMED, formerly the Navy-Marine Corps Combat Trauma Registry) was queried for all personnel injured during OIF who completed a Post-Deployment Health Assessment (PDHA). The EMED is a deployment health database maintained by NHRC and consists of documented clinical encounters of deployed military personnel.[23] Clinical EMED records are completed by medical providers as casualties move through the medical chain of military evacuation. Unique aspects of the EMED include detailed information regarding the injury incident, which is collected at or near the point of injury, as well as the inclusion of persons with otherwise mild injuries who are subsequently returned to duty. Clinical records are provided to NHRC and professional coders review the records and assign Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), and *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes.[24–26] The AIS ranges from 1 (minor) to 6 (unsurvivable) and is assigned to nine body regions. The ISS is a composite score based on the AIS and ranges from 1 to 75.

Eligible personnel for the present study were service members who sustained a deployment-related physical injury during OIF between 2004 and 2008, and who completed a PDHA between 30 and 180 days post-injury. The PDHA is a self-administered screening questionnaire developed by the US Department of Defense (DoD) to identify personnel in need of medical referral for a variety of health reasons spanning from mental health to physical complaints.[27] The PDHA has been used in previous research to identify population-level mental health screening rates.[28,29] For personnel with multiple injury episodes recorded in the EMED, only the most recent episode was included. Episodes indicating BI were given priority; i.e., if an individual sustained both a BI and NBI, only the BI record was included in the analysis. There were 8956 injured personnel in the EMED at the time of the analysis. Of these, 4802 had record of a PDHA, and 3412 completed a PDHA 1–6 months post-injury. An additional 9 individuals were excluded who failed to complete the PTSD screening instrument, leaving a final study sample of 3403 injured personnel.

Measures

Covariates. Demographic variables included in the analysis were age, military rank, and branch of service at the time of injury and were identified by the Defense Manpower Data Center (DMDC), which maintains electronic administrative records for all military personnel. Military rank was categorized as junior enlisted (E1–E4), mid-level enlisted (E5–E6), and senior enlisted/officer (E7 and above). Branch of service was categorized into Marine Corps, Army, and Navy/Air Force. Age at the time of injured deployment (18–24 years, 25 years and older), marital status (married, not married), education level (some college, no college), and service component (active duty, Reserve/National Guard) were identified from electronic DMDC deployment records.

Injury-specific variables were abstracted from the EMED clinical record. Injury group was classified as BI or NBI, with BI resulting from hostile action. Injury mechanism for BI was categorized into blast and non-blast following review of incident-specific information present on the EMED clinical record. ISS was categorized into mild, moderate, and serious-severe corresponding to a score of 1–3, 4–8, and 9 or greater, respectively, due to small numbers of serious-severe injuries among NBI. Presence of a head or neck injury was identified based on an AIS code assigned to the head or neck region.

Pre-injury variables of interest included previous deployment experience, previous mental health diagnosis, and previous BI. Personnel with a prior deployment were identified by presence of an electronic DMDC deployment record prior to their present deployment under study. Standard inpatient and outpatient medical databases were queried to identify presence of mental health diagnosis before injury, indicated by an ICD-9-CM code between 290 and 319 (excluding 305.1, tobacco addiction). This variable was further classified into mental health diagnosis occurring before the current injury and up to 1 year before deployment, and mental health diagnosis occurring outside of 1 year before deployment. Previous BI was identified from the EMED as any person with a documented BI prior to the injury of interest in the present study.

The PDHA contains questions that ask whether the service member was exposed to dead bodies, discharged his or her weapon, or had a perceived threat to life. The specific questions are shown in Table 1. For analyses including personnel with BI and NBI, numbers of "yes" responses were summed to create a "combat exposure" variable that ranged from zero to three positive responses. For analyses including only personnel with BI, those who endorsed zero or one combat exposures were combined due to small numbers. In order to further control for combat exposure, a variable indicating "infantry" or "noninfantry" occupation was created using the DoD standardized occupational codes from DMDC electronic records.

Main outcome measures. A positive screen for PTSD was ascertained from the PDHA, which contains a validated four-item PTSD screening instrument shown in Table 1. This four-item screening instrument is based on the Primary Care PTSD screen, and endorsing any three of the four symptoms indicated a positive screen for PTSD.[30] This PTSD screening instrument was recently validated against the more widely used 17-item PTSD Checklist.[31]

Statistical analysis

All statistical analyses were performed using SAS software, version 9.2 (SAS Institute Inc., Cary, NC). Covariates were described for the study sample stratified by BI and NBI. Chi-square and

Table 1
Posttraumatic stress and combat exposure questions from the Post-Deployment Health Assessment.

Posttraumatic stress	Combat exposure
Have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month, you…	Did you see anyone wounded, killed or dead during this deployment? (yes/no)
Have had any nightmares about it or thought about it when you did not want to? (yes/no)	Were you engaged in direct combat where you discharged your weapon? (yes/no)
Tried hard not to think about it or went out of your way to avoid situations that remind you of it? (yes/no)	During this deployment, did you ever feel that you were in great danger of being killed? (yes/no)
Were constantly on guard, watchful, or easily startled? (yes/no)	
Felt numb or detached from others, activities, or your surroundings? (yes/no)	

Kruskal–Wallis tests were used to examine categorical and continuous variables, respectively. Logistic regression was used for univariate and multivariable analyses. Three models were used to estimate the odds ratio (OR) and confidence intervals (CIs) for the comparison of BI and NBI. Model 1 was adjusted for demographic variables only (age, rank, branch, sex, component, college education, and marital status), model 2 for demographics plus injury severity, and model 3 for demographics, injury severity, and combat exposure. Separate models were also constructed to assess injury-specific and pre-injury predictors of PTSD following BI. All multivariable models were adjusted for age and other demographic characteristics. The Hosmer–Lemeshow test was used to assess goodness of fit.

Results

A total of 3403 injuries, 1777 BI and 1626 NBI, between 2004 and 2008 were identified from the EMED and matched to a PDHA completed 30–180 days post-injury. Of the 1777 personnel with BI, 89% were attributed to a blast, while the remaining 11% were due to other, non-blast causes. The predominant mechanism of injury among those with NBI was musculoskeletal overexertion (42%), and blunt, fall, motor vehicle accidents, and other/unknown comprised the remaining 58%.

Descriptive characteristics for the sample are presented in Table 2. The distribution of all variables differed significantly by type of injury. Most notably, those with BI sustained a larger proportion of moderate and serious-severe injuries compared with NBI (19.4% vs. 11.2% and 5.5% vs. 0.5%, $p < 0.001$), and they were also more likely to report two–three combat exposures (88.4% vs. 35.5%, $p < 0.001$). Compared with NBI, those with BI were younger (69.6% vs. 57.1%, $p < 0.001$), of more junior rank (E1–E4, 76.3% vs. 67.0%, $p < 0.001$), and less likely to be married (36.3% vs. 45.8%, $p < 0.001$). The NBI sample, compared with the BI sample, had a higher proportion of women (10.1% vs. 1.0%, $p < 0.001$), Navy/Air Force service members (17.0% vs. 6.5%, $p < 0.001$), and Reserve/National Guard (21.7% vs. 17.5%, $p = 0.002$).

Table 3 presents the results for univariate and multivariable analyses for a positive PTSD screen in personnel with BI and NBI. Approximately 25% of those with BI also screened positive for PTSD compared to only 6.6% of those with NBI (unadjusted OR, 4.72; 95% CI, 3.78–5.90). Adjusting for demographic variables and injury severity did not considerably alter the association between BI and PTSD. After additional adjustment for combat exposure, however, the magnitude of the association between BI and PTSD was reduced by more than half (OR, 2.10; 95% CI, 1.60–2.75), but remained statistically significant. The Hosmer–Lemeshow test indicated this model was a good fit ($p = 0.38$)

Sample characteristics and univariate and multivariable statistics for personnel with BI are shown in Table 4. The highest rates of PTSD screen positive were in those personnel who served in the Army (33.2%), were aged 25 years or older (30.0%), and married (28.4%). Prior deployment was indicated for 38.7% of those with BI, and a record of prior BI was identified for 5.1%. A previous mental health diagnosis was identified in 3.3% of personnel within 1 year prior to the beginning of the deployment with the present injury. An additional 3.2% of the personnel had a mental health diagnosis more than 1 year prior to the beginning of the deployment. After adjustment, predictors of PTSD among those with BI included moderate and serious-severe injury severity (OR, 1.49; 95% CI, 1.11–2.00 and OR, 1.64; 95% CI, 1.01–2.68, respectively), prior BI (OR, 1.96; 95% CI, 1.22–3.16), and mental health diagnosis within 1 year pre-deployment (OR, 2.69; 95% CI, 1.50–4.81). The strongest predictor of PTSD was reporting two and three combat exposures (OR, 7.58; 95% CI, 3.44–16.74 and OR, 13.85; 95% CI, 6.36–30.16), respectively. A positive PTSD screen among those with BI was also associated with older age, lower rank, service in the Army, being married, and Reserve/National Guard status. The Hosmer–Lemeshow goodness of fit test indicated the model fit the data ($p = 0.98$).

Discussion

To our knowledge, this study represents the largest analysis of BI and NBI in relation to subsequent positive PTSD screen. Our findings confirmed that an injury occurring in battle compared with non-battle circumstances was strongly associated with PTSD, independent of injury severity and combat exposure. There were vast differences in population characteristics between those who sustain BI compared with NBI, particularly in the degree of combat exposure. Without taking these differences into account, it would be difficult to estimate the true contributing effect of BI on PTSD. The identification of pre-injury variables associated with PTSD following BI may allow clinicians and commanders to better identify high-risk subgroups and treat those affected. Most importantly, these findings establish BI as a significant predictor of PTSD symptoms, which may warrant more focused screening for such injuries on post-deployment questionnaires.

In contrast to our analysis, a recent study among wounded service members treated at a US burn center found no difference in rates of PTSD between those injured in battle versus those injured in non-battle circumstances.[32] This difference in findings may be because personnel treated at a burn center might have more severe, disabling injuries overall, regardless of the cause of injury. One study that supports our findings examined PTSD rates following injury in civilians and found a higher incidence of PTSD among survivors of terrorist attacks admitted to local emergency rooms compared with survivors of motor vehicle accidents.[33] Although not battle-related injury, trauma resulting from terrorism may be a similar phenomenon specific to the civilian community. Our finding that history of BI increases the risk of PTSD provides further evidence in support of the relationship between BI and PTSD. This result also suggests a possible dose–response relationship. Because many battle casualties may return to full duty status within days after injury, there is a risk of repeat

Table 2
Sample characteristics, battle and non-battle injured personnel, Operation Iraqi Freedom 2004–2008 ($n = 3403$).

Characteristic	Battle injury ($n = 1777$)	Non-battle injury ($n = 1626$)	p
Demographics			
Age, years, no. (%)			<0.001
18–24	1237 (69.6)	929 (57.1)	
25+	540 (30.4)	697 (42.9)	
Rank, no. (%)			<0.001
E1–E4	1356 (76.3)	1090 (67.0)	
E5–E6	301 (16.9)	367 (22.6)	
E7+	120 (6.8)	169 (10.4)	
Branch, no. (%)			<0.001
Marine Corps	1219 (68.6)	1107 (68.1)	
Army	443 (24.9)	243 (14.9)	
Navy/Air Force	115 (6.5)	276 (17.0)	
Sex, no. (%)			<0.001
Male	1757 (98.9)	1451 (89.2)	
Female	20 (1.1)	175 (10.8)	
Component, no. (%)			0.002
Active duty	1466 (82.5)	1273 (78.3)	
Reserve/National Guard	311 (17.5)	353 (21.7)	
College, no. (%)[a]			0.020
None	1582 (90.6)	1412 (88.1)	
Some	164 (9.4)	190 (11.9)	
Married, no. (%)			<0.001
No	1132 (63.7)	882 (54.2)	
Yes	645 (36.3)	744 (45.8)	
Combat-related			
Infantry, no. (%)			<0.001
No	649 (36.5)	1310 (80.6)	
Yes	1128 (63.5)	316 (19.4)	
Combat exposures, no. (%)[b]			<0.001
0	55 (3.1)	625 (38.4)	
1	152 (8.6)	423 (26.0)	
2	531 (29.9)	366 (22.5)	
3	1038 (58.5)	212 (13.0)	
Injury-specific			
ISS, no. (%)			<0.001
Mild	1335 (75.1)	1436 (88.3)	
Moderate	344 (19.4)	182 (11.2)	
Serious-severe	98 (5.5)	8 (0.5)	
Mean days to PDHA (SD)	99.9 (41.8)	95.7 (40.9)	0.003

ISS, Injury Severity Score; PDHA, Post-Deployment Health Assessment; SD, standard deviation.
[a] Missing data ($n = 55$).
[b] Missing data ($n = 1$).

injury and as such, the efficient evaluation, treatment, and on-site rehabilitation of combat casualties is necessary.

Post-deployment screening programs may benefit from querying individuals on the occurrence of BI during deployment, particularly since most BI incidents are minor and may not be accurately documented in the individual's medical record. Neither version of the PDHA (2003 and 2008 versions) directly asks service members specifically about BI. Although the 2008 version does include additional general injury-related questions, it still does not have a specific combat injury question. A recent study by Baker et al. found responding "yes" to such a question was associated with a three-times higher risk of PTSD.[34] Further, it may be useful to question whether an individual sustained more than one combat injury. Inclusion of these questions into an overall PTSD risk profile may help identify those who would possibly benefit from more focused mental health evaluation, especially those who intentionally do not answer the PTSD screen truthfully due to stigma concerns but are more comfortable answering general questions regarding combat experiences.

The association of previous mental health diagnosis within the year preceding deployment was consistent with civilian literature suggesting a similar relationship.[35–37] Additionally, a recent population-based study identified baseline mental health symptoms as predictors of PTSD following deployment-related injury in a military population.[20] That study, however, did not distinguish between BI and NBI and used screening instruments to identify baseline mental health symptoms, rather than previous mental health diagnoses. These screening instruments are not readily used in the pre-deployment screening process and as such, their utility in military populations is limited. The use of mental health

Table 3
Logistic regression analysis, battle, and non-battle injury with posttraumatic stress disorder outcome.

	PTSD		Unadjusted	Adjusted OR (95% CI)		
Type of injury	No.	%	OR (95% CI)	Demographics[a]	Demographics and ISS[b]	Demographics, ISS and combat-related[c]
Non-battle	108	6.6	Ref			
Battle	447	25.2	4.72 (3.78–5.90)	4.99 (3.91–6.35)	4.75 (3.72–6.06)	2.10 (1.60–2.75)

CI, confidence interval; ISS, Injury Severity Score; OR, odds ratio; PTSD, posttraumatic stress disorder.
[a] Adjusted model included the demographic variables, age, rank, branch, sex, component, college education, and marital status.
[b] Adjusted model included all demographic variables and ISS.
[c] Adjusted model included all demographic variables, ISS, infantry status, and number of combat exposures.

Table 4
Predictors of posttraumatic stress disorder among personnel injured during battle in Operation Iraqi Freedom ($n = 1777$).

Variable		PTSD		Unadjusted OR (95% CI)	Adjusted OR (95% CI)
	n	No.	%		
Demographics					
Age, years, no. (%)					
18–24	1237	285	23.0	Ref	
25+	540	162	30.0	1.43 (1.14–1.80)	1.63 (1.17–2.27)
Rank, no. (%)					
E1–E4	1356	347	25.6	Ref	
E5–E6	301	77	25.6	1.00 (0.75–1.33)	0.54 (0.37–0.79)
E7+	120	23	19.2	0.69 (0.43–1.10)	0.30 (0.15–0.51)
Branch, no. (%)					
Marine Corps	1219	275	22.6	Ref	
Army	443	147	33.2	1.71 (1.34–2.17)	1.43 (1.07–1.90)
Navy/Air Force	115	25	21.7	0.95 (0.60–1.52)	0.81 (0.47–1.39)
Sex, no. (%)					
Male	1757	441	25.1	Ref	
Female	20	6	30.0	1.28 (0.49–3.35)	2.27 (0.75–6.84)
Component, no. (%)					
Active duty	1466	347	23.7	Ref	
Reserve/National Guard	331	100	32.2	1.53 (1.17–2.00)	1.47 (1.08–2.00)
College, no. (%)[a]					
None	1582	401	25.4	Ref	
Some	164	40	24.4	0.95 (0.65–1.38)	1.05 (0.66–1.66)
Married, no. (%)					
No	1132	264	23.3	Ref	
Yes	645	183	28.4	1.30 (1.05–1.62)	1.32 (1.02–1.70)
Combat-related					
Infantry, no. (%)					
No	649	148	22.8	Ref	
Yes	1128	299	26.5	1.22 (0.97–1.53)	1.01 (0.77–1.33)
Combat exposures, no. (%)[b]					
0–1	207	7	3.4	Ref	
2	531	112	21.1	7.64 (3.49–16.69)	7.58 (3.44–16.74)
3	1038	328	31.6	13.20 (6.14–28.36)	13.85 (6.36–30.16)
Injury-specific					
ISS, no. (%)					
Mild	1335	301	22.6	Ref	
Moderate	344	113	32.9	1.68 (1.30–2.18)	1.49 (1.11–2.00)
Serious-severe	98	33	33.7	1.74 (1.13–2.70)	1.64 (1.01–2.68)
Blast					
No	196	47	24.0	Ref	
Yes	1581	400	25.3	1.07 (0.76–1.52)	1.13 (0.77–1.66)
Head/neck injury					
No	957	227	23.7	Ref	
Yes	820	220	26.8	1.18 (0.95–1.46)	1.12 (0.87–1.44)
Pre-injury					
Prior deployment					
No	1089	269	24.7	Ref	
Yes	688	178	25.9	1.06 (0.85–1.32)	1.16 (0.91–1.49)
Prior battle injury					
No	1686	413	24.5	Ref	
Yes	91	34	37.4	1.84 (1.19–2.85)	1.96 (1.22–3.16)
Prior MH diagnosis					
No	1662	408	24.6	Ref	
>1 year pre-deployment	56	13	23.2	0.93 (0.50–1.75)	0.83 (0.43–1.64)
Within 1 year pre-deployment	59	26	44.1	2.42 (1.43–4.10)	2.69 (1.50–4.81)

CI, confidence interval; ISS, Injury Severity Score; MH, mental health; OR, odds ratio; PTSD, posttraumatic stress disorder.
[a] Missing data ($n = 31$).
[b] Missing data ($n = 1$).

diagnosis codes is more feasible, since all personnel have their medical records reviewed during pre-deployment screening, and those with a recent mental health diagnosis can be identified and targeted for more focused evaluation to determine deployment suitability.

There were secondary findings of interest. A positive association was identified between injury severity and PTSD, which is consistent with recent studies in military populations.[20,38] Similarly consistent with previous literature, combat exposure was the strongest predictor of PTSD.[39] Combat exposure should be used with BI information to establish and expand the PTSD risk profile. There was no association found between head/neck injury location with PTSD. Given the recent attention paid to the mental health effects of mild traumatic brain injury (TBI),[40] this is somewhat unexpected, though recent literature regarding the etiological relationship between TBI and PTSD is mixed.[22,41]

The primary strengths of the present study were the large sample size of both BI and NBI, as well as the wide range of injury severity in the study population. Additionally, the use of electronic databases coupled with knowledge of precise injury date from the EMED allowed for the unbiased assessment of pre-injury variables. The use of PDHA information to assign outcome greatly reduced the potential for medical utilization bias, and allowed for the concomitant assessment of and adjustment for combat exposure.

The primary limitation of the study was the potential for non-response bias in PDHA completion, which was identified in a previous study examining injuries during wartime.[19] It was found that the PDHA compliance rate may be significantly reduced among those with more severe injuries, which could possibly obscure the effects of injury severity. Further, the lack of serious-severe injuries among NBI resulted in a broad categorization of injury severity. Additionally, the sample of EMED cases used consisted of expeditionary medical encounters and therefore, was more heavily skewed toward data collected at Navy-Marine Corps medical facilities only, thus injuries among Army personnel are underrepresented. Therefore, the identified associations may be more representative of Navy and Marine Corps personnel.

Conclusions

The present analysis identified a strong positive association of BI and subsequent screening for PTSD, relative to NBI, and implicated prior BI, recent previous mental health diagnosis and injury severity as additional associated factors. These findings advance the existing body of literature on the psychiatric sequelae of physical injury, particularly those sustained in battle, which are becoming increasingly frequent during current wartime operations. Future research should investigate potential refinements in the post-deployment screening process in order to identify personnel who were injured as a result of combat. This could lead to the development of a PTSD risk profile that should be used in conjunction with the existing PTSD screening instrument to identify groups in need of intervention. As twenty-first century medical advances maximize survivability, clinical focus should shift toward the psychological consequences of battlefield injuries and concentrate on improving the mental health treatment of the wounded.

Conflicts of interest

The authors declare no conflicts of interest.

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References

1. Hyams KC, Wignall FS, Roswell R. War syndromes and their evaluation: from the U.S. Civil War to the Persian Gulf War. *Annals of Internal Medicine* 2006;**125**:398–405.
2. Jones E. Historical approaches to post-combat disorders. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences* 2006;**361**:533–42.
3. Rosen G. Nostalgia: a ‘‘forgotten’’ psychological disorder. *Psychological Medicine* 1975;**5**:340–54.
4. Southborough L. *Report of the War Office Committee of inquiry into ‘‘shell-shock’’*. London, UK: Her Majesty’s Stationery Office; 1922.
5. Jones E, Wessely S. Psychiatric battle casualties: an intra- and interwar comparison. *British Journal of Psychiatry* 2001;**178**:242–7.
6. Archibald HC, Tuddenham RD. Persistent stress reaction after combat: 20-year follow-up. *Archives of General Psychiatry* 1965;**12**:475–81.
7. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. 3rd ed. Washington, DC: American Psychiatric Association; 1980.
8. Boyle CA, Decouflé P, O’Brien TR. Long-term health consequences of military service in Vietnam. *Epidemiologic Reviews* 1989;**11**:1–27.
9. Centers for Disease Control. Health status of Vietnam veterans. I. Psychosocial characteristics. The Centers for Disease Control Vietnam Experience Study. *JAMA* 1988;**259**:2701–7.
10. Stimpson NJ, Thomas HV, Weightman AL, Dunstan R, Lewis G. Psychiatric disorder in veterans of the Persian Gulf War of 1991. *British Journal of Psychiatry* 2003;**182**:391–403.
11. Hoge CW, Auchterlonie JL, Milliken CS. Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. *JAMA* 2006;**295**:1023–31.
12. Seal KH, Bertenthal D, Miner CR, Sen S, Marmar C. Bringing the war back home: mental health disorders among 103,788 US veterans returning from Iraq and Afghanistan seen at Department of Veterans Affairs facilities. *Archives of Internal Medicine* 2007;**167**:476–82.
13. Cullison A. On distant battlefields, survival odds rise sharply. *Wall Street Journal* 2011;**26** Available at:*http://online.wsj.com/article/SB10001424052748704655004575114623837930294.html*. [accessed September].
14. Wood P. Aetiology of Da Costa’s syndrome. *British Medical Journal* 1941;**1**: 845–51.
15. Merbaum M, Hefez A. Some personality characteristics of soldiers exposed to extreme war stress. *Journal of Consulting and Clinical Psychology* 1976;**44**:1–6.
16. Pitman RK, Altman B, Macklin ML. Prevalence of posttraumatic stress disorder in wounded Vietnam veterans. *American Journal of Psychiatry* 1989;**146**:667–9.
17. Helzer JE, Robins LN, McEvoy L. Post-traumatic stress disorder in the general population. Findings of the Epidemiologic Catchment Area survey. *New England Journal of Medicine* 1987;**317**:1630–4.
18. Koren D, Norman D, Cohen A, Berman J, Klein EM. Increased PTSD risk with combat-related injury: a matched comparison study of injured and uninjured soldiers experiencing the same combat events. *American Journal of Psychiatry* 2005;**162**:276–82.
19. MacGregor AJ, Shaffer RA, Dougherty AL, Galarneau MR, Raman R, Baker DG, *et al.* Psychological correlates of battle and nonbattle injury among Operation Iraqi Freedom veterans. *Military Medicine* 2009;**174**:224–31.
20. Sandweiss DA, Slymen DJ, LeardMann CA, Smith B, White MR, Boyko EJ, *et al.* Preinjury psychiatric status, injury severity, and postdeployment posttraumatic stress disorder. *Archives of General Psychiatry* 2011;**68**:496–504.
21. Brandt GT, Norwood AE, Ursano RJ, Wain H, Jaccard JT, Fullerton CS, *et al.* Psychiatric morbidity in medical and surgical patients evacuated from the Persian Gulf War. *Psychiatric Services* 1997;**48**:102–4.
22. Carlson KF, Nelson D, Orazem RJ, Nugent S, Cifu DX, Sayer NA. Psychiatric diagnoses among Iraq and Afghanistan war veterans screened for deployment-related traumatic brain injury. *Journal of Traumatic Stress* 2010;**23**:17–24.
23. Galarneau MR, Hancock WC, Konoske P, Melcer T, Vickers RR, Walker GJ, *et al.* The Navy-Marine Corps Combat Trauma Registry. *Military Medicine* 2006;**171**: 691–7.
24. Gennarelli T, Wodzon E. *The abbreviated injury scale – 2005*. Des Plaines, IL: Association for the Advancement of Automotive Medicine; 2005.
25. Baker SP, O’Neill B, Haddon W, Long WB. The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma* 1974;**14**:187–96.
26. Commission on Professional Hospital Activities. *International classification of diseases, 9th revision, clinical modification*. Ann Arbor, MI: Edwards Brothers; 1977.
27. Enhanced Post-Deployment Health Assessment (PDHA) process (DD Form 2796). Available at: http://www.pdhealth.mil/dcs/DD_form_2796.asp [accessed 06.09.11].
28. Hoge CW, Auchterlonie JL, Milliken CS. Mental health problems, use of mental health services, and attrition from military service after returning from deployment to Iraq or Afghanistan. *JAMA* 2006;**295**:1023–32.
29. Milliken CS, Auchterlonie JL, Hoge CW. Longitudinal assessment of mental health problems among active and reserve component soldiers returning from the Iraq war. *JAMA* 2007;**298**:2141–8.
30. Prins A, Ouimette P, Kimerling R, Cameron RP, Hugelshofer DS, Shaw-Hegwer J, *et al.* The Primary Care PTSD screen (PC-PTSD): development and operating characteristics. *Primary Care Psychiatry* 2004;**9**:9–14.
31. Bliese PD, Wright KM, Adler AB, Cabrera O, Castro CA, Hoge CW. Validating the Primary Care Posttraumatic Stress Disorder screen and the Posttraumatic Stress Disorder Checklist with soldiers returning from combat. *Journal of Consulting and Clinical Psychology* 2008;**76**:272–81.
32. Gaylord KM, Holcomb JB, Zolezzi ME. A comparison of posttraumatic stress disorder between combat casualties and civilians treated at a military burn center. *Journal of Trauma* 2009;**66**(Suppl. 4):S191–5.
33. Shalev AY, Freedman S. PTSD following terrorist attacks: a prospective evaluation. *American Journal of Psychiatry* 2005;**162**:1188–91.
34. Baker DG, Heppner P, Afari N, Nunnink S, Kilmer M, Simmons A, *et al.* Trauma exposure, branch of service, and physical injury in relation to mental health among U.S. veterans returning from Iraq and Afghanistan. *Military Medicine* 2009;**174**:773–7.
35. Mason S, Wardrope J, Turpin G, Rowlands A. The psychological burden of injury: an 18 month prospective cohort study. *Emergency Medicine Journal* 2002;**19**: 400–4.
36. Hapke U, Schumann A, Rumpf HJ, John U, Meyer C. Post-traumatic stress disorder: the role of trauma, pre-existing psychiatric disorders, and gender. *European Archives of Psychiatry and Clinical Neuroscience* 2006;**256**:299–306.

37. Fauerbach JA, Lawrence J, Haythornthwaite J, Richter D, McGuire M, Schmidt C, *et al.* Preburn psychiatric history affects posttrauma morbidity. *Psychosomatics* 1997;**38**:374–85.
38. MacGregor AJ, Corson KS, Larson GE, Shaffer RA, Dougherty AL, Galarneau MR, *et al.* Injury specific predictors of posttraumatic stress disorder. *Injury* 2009;**40**:1004–10.
39. Phillips CJ, Leardmann CA, Gumbs GR, Smith B. Risk factors for posttraumatic stress disorder among deployed US male marines. *BMC Psychiatry* 2010;**25**:52.
40. Adamson DM, Burnam MA, Burns RM, Caldarone LB, Cox RA, D'Amico E, *et al.* *Invisible wounds of war: psychological and cognitive injuries, their consequences, and services to assist recovery*. Santa Monica, CA: RAND Corporation; 2008In: *http://www.rand.org/pubs/monographs/MG720*.
41. Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA. Mild traumatic brain injury in U.S. soldiers returning from Iraq. *New England Journal of Medicine* 2008;**358**:453–63.

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6. AUTHORS
Andrew J. MacGregor, Janet J. Tang, Amber L. Dougherty, Michael R. Galarneau

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Commanding Officer
Naval Health Research Center
140 Sylvester Rd
San Diego, CA 92106-3521

8. PERFORMING ORGANIZATION REPORT NUMBER
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8. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
Commanding Officer
Naval Medical Research Center
503 Robert Grant Ave
Silver Spring, MD 20910-7500

Chief, Bureau of Medicine and Surgery
7700 Arlington Blvd
Falls Church, VA 22042

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14. ABSTRACT

The current military conflicts in Iraq and Afghanistan have resulted in the most US casualties since the Vietnam War. Previous research on the association between deployment-related injury and posttraumatic stress disorder (PTSD) has yielded mixed results. The objective of the present study was to examine the effect of battle injury (BI) relative to nonbattle injury (NBI) on the manifestation of PTSD symptoms in military personnel and to assess the demographic, injury-specific, and pre-injury factors associated with PTSD following a BI. A total of 3,403 people with deployment-related injury (1,777 BI and 1,626 NBI) were identified from the Expeditionary Medical Encounter Database. Records were electronically matched to Post-Deployment Health Assessment (PDHA) data completed 1–6 months post-injury. The PTSD screening outcome was identified using a four-item screening tool on the PDHA. Compared to those with NBI, personnel with BI had more severe injuries, reported higher levels of combat exposure, and had higher rates of positive PTSD screen. After adjusting for covariates, personnel with BI were twice as likely to screen positive for PTSD compared to those with NBI (odds ratio [OR], 2.10; 95% confidence interval [CI], 1.60–2.75). In multivariate analysis among battle-injured personnel only, moderate and severe injury (OR, 1.49; 95% CI, 1.12–2.00 and OR, 1.64; 95% CI, 1.01–2.68, respectively), previous mental health diagnosis within 1 year of deployment (OR, 2.69; 95% CI, 1.50–4.81), and previous BI (OR, 1.96; 95% CI, 1.22–3.16) predicted a positive PTSD screen. Military personnel with battle injury have increased odds of positive PTSD screen following combat deployment. Post-deployment health questionnaires may benefit from questions that specifically address whether service members experienced an injury during combat.

15. SUBJECT TERMS
injury, PTSD, military, combat

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